P-SO-01

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Laser Produced Plasma EUV Source Development for Mass Production of sub-20nm Devices

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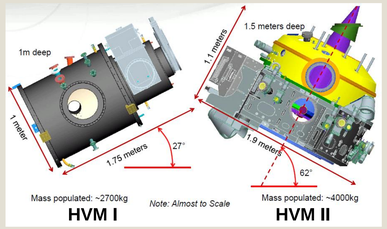
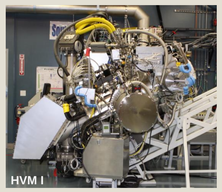
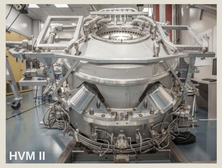
1. LASER-PLASMA SOURCE CONFIGURATION



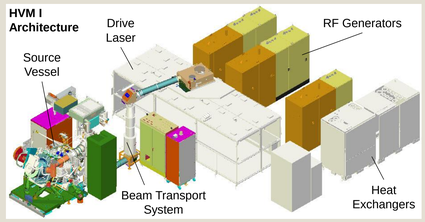
HVM II oriented at a steeper angle than HVM I, enabling ~2x higher optical transmission in scanner

Additional power amplifier on HVM II system enables higher laser power than HVM I





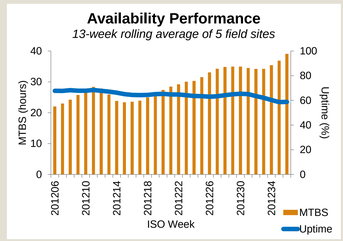
Three major subsystems of source architecture:
- Drive Laser
- Beam Transport System
- Source Vessel



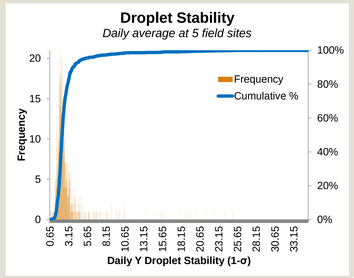
2. HVMI FIELD PERFORMANCE

In the Field: 9-13W Average Power with <0.5% Dose Stability

- SEMI E10 availability of sources in field approximately ~60%
- Droplet stability <3nm for 80% of days YTD
- Capability for >100 wafers per day throughput



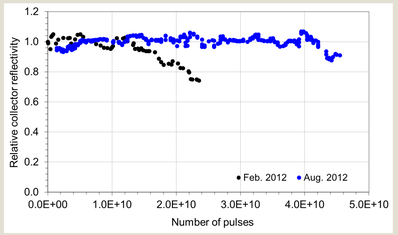
MTBS increasing, Uptime in slight decline (SEMI E10 data)

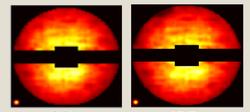


8. COLLECTOR LIFETIME

Major Improvements to Collector Lifetime

IMPROVED COLLECTOR LIFETIME IN FIELD

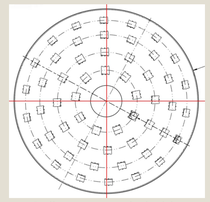




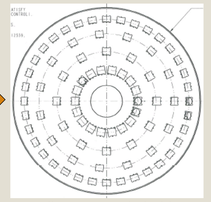
EUV distributions measured by scanner

- ~2x increase in lifetime, compared to six months prior
- No degradation in collector reflectivity up to 40 Bp

MULTIPLE MLM COATING TESTS IN PARALLEL

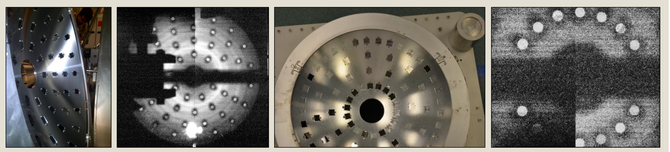


Collector sample holder (54 samples)



Collector sample holder (92 samples)

~2x improved capacity for testing multiple MLM coatings in parallel



Photos of collector sample holder and far-field EUV images of samples under test (54 sample holder left, 92 sample holder right)

3. POWER ROADMAP

Dedicated test source for Prepulse

40-60 W Average Expose Power
- <±0.5% Dose Stability
- Continuous mode with Prepulse

20W Average Expose Power
- <±0.5% Dose Stability
- Burst mode, 90% duty cycle

Dedicated test source for 20W Power

10-13 W Average Expose Power
- <±0.5% Dose Stability
- Burst mode, 60% duty cycle

Available for Chipmaker

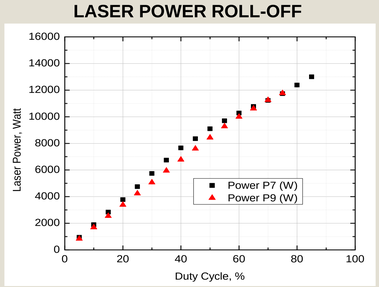
Now Q4 Q2

Source Model	HVM I	HVM II			
Average Laser Power (kW)	20	23	24	31	43
In-Band CE (%)	2.0	2.0	2.5	2.5	3.0
Clean EUV Power (W)	60	80	125	160	250

4. EUV POWER SCALING

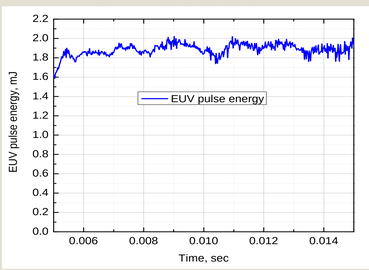
~1.9mJ EUV pulse energy and 158W EUV power demonstrated on pilot sources at Cymer

LASER POWER ROLL-OFF



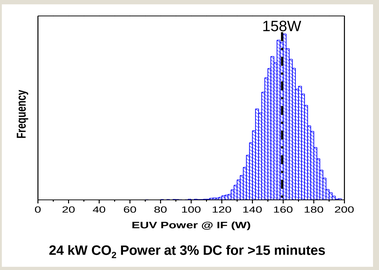
Near-linear laser power scaling up to 85% duty cycle shown on both Pilot 7 and 9

EUV PULSE ENERGY



~1.9 mJ EUV per pulse demonstrated at 50kHz on Pilot 7, equivalent to 90W EUV power

EUV POWER CAPABILITY DEMO

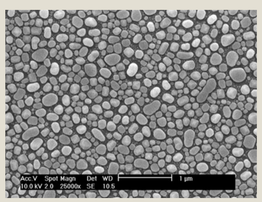


24 kW CO_2 Power at 3% DC for >15 minutes

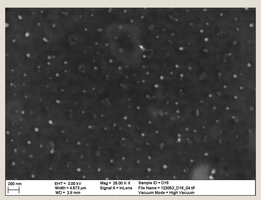
158W raw power and 190W peak raw power shown in low duty cycle demonstration on LT1

5. DEBRIS MITIGATION

Tin cleaning during source operation



SEM image of sample before installation into source chamber with 32 nm thick layer of tin deposited

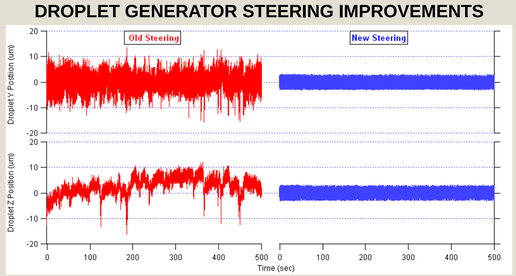


SEM image of sample above after source operation, thickness of tin is 2 nm, measured with X-Ray Fluorescence (XRF)

6. DROPLET STABILITY

New steering leads to improved dose stability

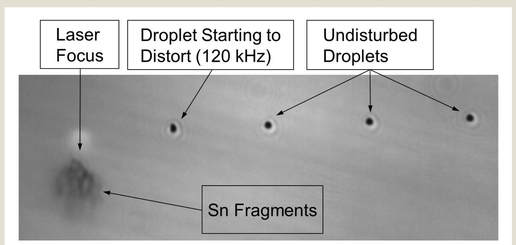
DROPLET GENERATOR STEERING IMPROVEMENTS



Improved droplet stability with new droplet generator steering (σ_y, σ_z: 2.8, 3.2 to 1.1, 1.3 μm)

7. EUV AT HIGH REPITITION RATE

STABILITY MAINTAINED WITH REP RATE INCREASE



Repetition rate can be increased to >60kHz without disrupting next droplet (Image shows 30 um droplets at 120 kHz with 500 um droplet spacing)

9. SUMMARY

- 10 HVM I sources installed and operational
- HVM I source EUV average power ~9-13W in field with better than <0.5% dose stability and capability of >100 wafers per day productivity
- Collector lifetime of 45 billion pulses achieved in field
- 50W expose power demonstrated with closed loop control for over five hours of continuous operation; up to 90W in-burst power demonstrated; 160W peak raw power shown on development tool
- First HVM II source for ASML NXE 3300 scanner is delivered, integration of the next several is in process

This work is supported by our technology partners: